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1392A
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1402B
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1405H
1406H
1410N

INSTALLATION
OPERATION
MAINTENANCE

INSTRUCTION MANUAL

WELCH

DUO-SEAL®

VACUUM

PUMPS

MP MASTER
MA25579

THE WELCH SCIENTIFIC COMPANY
Established in 1880
7300 N. LINDER AVENUE, SKOKIE, ILLINOIS 60076

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WELCH DUO-SEAL VACUUM PUMPS are mechanical, rotary, oil-sealed, vane-type pumps of one- or two-stage construction. Their superior design and precision manufacture achieves high volumetric efficiency and low ultimate pressure — qualities which have made them the leading choice for all applications of rotary, oil-sealed vacuum pumps.

Welch's exceptionally high standards in manufacture, continuous testing and assembly by skilled craftsmen result in long life and extremely low maintenance. All pumps are thoroughly run-in and frequently tested to reach a performance level which surpasses their guarantee.

The following pages cover the installation, operation and maintenance of your Duo-Seal Pump. These instructions should be read carefully before operating the pump or attempting repairs. Complete instructions are included for routine servicing of the pump and motor.

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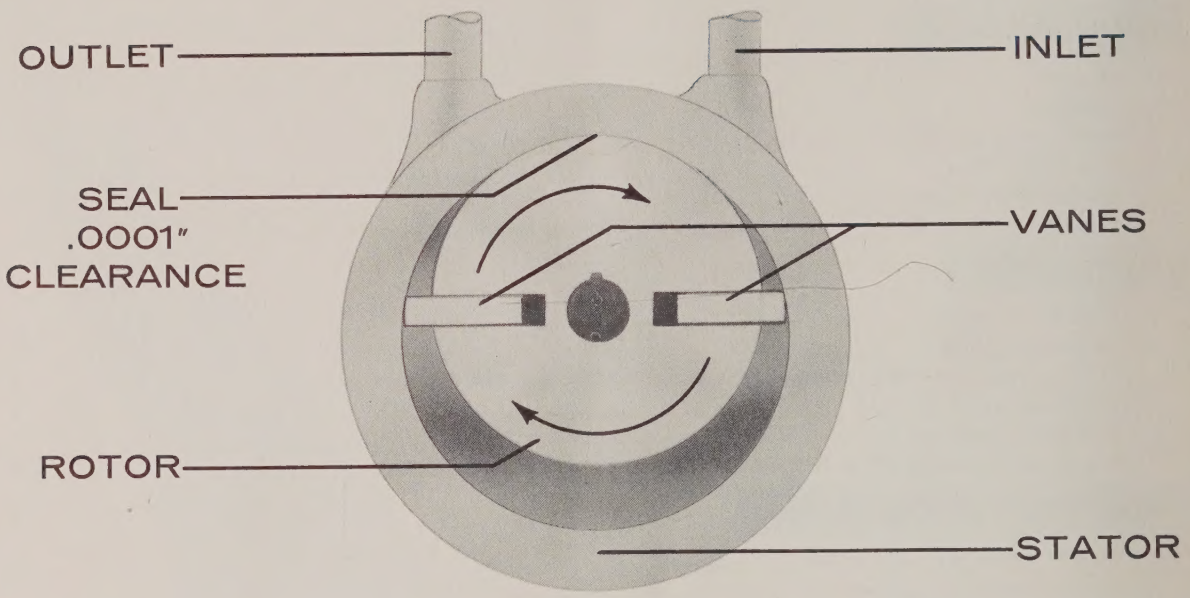


PRINCIPLES OF OPERATION

Each stage of the Welch Duo-Seal Pumps consists of a rotor, mounted concentrically on the drive shaft and positioned eccentrically in a cylindrical stator. The contact area of the rotor and stator is called the SEAL. It is a cylindrical seat machined into the stator, with the same radius as the rotor, and located between the inlet and outlet of the pump. The rotor is fitted with two spring loaded, diametrically-opposed vanes which move in and out of their slots, always pressing against the inner surface of the stator ring. Any wear on the vanes is reduced to a very insignificant amount because of a thin oil film which lubricates all parts of the pump. As a vane leaves the seal, it sweeps the air from the crescent-shaped space and forces it out the one-way exhaust valve. This operation is repeated twice each revolution, reducing the pressure in the vessel connected to the intake, thereby achieving a higher and higher vacuum. A patented feature called the Duo-Seal provides a by-pass at the seal. This by-pass carries the last increment of gas, which may escape the port, back to the exhaust stage. It eliminates the possibility of entraining the gas into the intake stage and re-pumping it.

The operating combination of stator, rotor and vanes constitutes the vital part of the pump. One of these units is used in a single-stage pump. In a two-stage pump, two of these units are connected in series and mounted on a common drive shaft for better ultimate vacuum.

VENTED EXHAUST

The presence of water or other vapors in the vacuum system can be very detrimental to the performance of the pump. They may contaminate the oil, and if corrosive, they will damage the pump parts. One method of removing such vapors is using cold traps between the pump and vacuum system. A vented exhaust valve on the pump will give additional protection.

The vented exhaust minimizes the condensation of vapors in the compression cycle of the exhaust stage by introducing an adjustable flow of atmospheric air. The diluting effect of the admitted air lowers the partial pressure of the vapor below its saturation pressure at the operating temperature of the pump. This prevents condensation and the vapors are expelled with the exhaust gases.

The vented exhaust is also helpful in removing condensed vapors from previously contaminated oil. Method of use and adjustment is described on page 5 under "Operation".

UNPACKING

Remove the pump from the shipping case with care. If any damage has occurred, file claim with the carrier immediately. Always save the shipping container for carrier inspection.

If it is necessary to communicate with your dealer or The Welch Scientific Company, please include your order number, pump catalog number and serial number to expedite replacement. *Do not return the pump to the factory* without obtaining shipping instructions.

INSTALLATION

MOUNTING

Welch Pump-Motor Sets are furnished mounted on formed steel bases, supported on rubber bumpers. These units should be placed on a firm foundation. See instructions for No. 1392 and No. 1392A Mechanical-Diffusion Pump Combinations at the end of this section.

All Duo-Seal Pumps have supporting legs drilled for mounting bolts.

The pump should be located in a clean area with good ventilation, and as close as possible to the vacuum system to which it will be attached. Adequate space should be allowed around the pump for normal maintenance, such as oil changes, belt adjustments, etc. Before operation, check belt tension and pulley alignment.

The pumps are air-cooled, eliminating the need for cooling water.

ELECTRICAL

Care should be taken to insure that the electric motor is connected to the correct voltage, phase and frequency. Check the motor wiring connection by removing motor plate and comparing connections with diagram on inside of plate. Pump-motor sets (other than explosion proof and 3 phase motors) are furnished with a switch and cord. The cord can be plugged directly into the proper receptacle.

If the electric motor to be used is not furnished by Welch, be sure that the motor, belt and pulley will operate the pump at the proper speed.

Check the rotational direction of the motor before connecting belt to pump pulley.

CONNECTION TO SYSTEM

The connecting line between the pump and the vessel to be evacuated should be as short as practical and as free from bends as circumstances permit. The inner diameter should be at least as large as the inside diameter of the pump intake. (See page 14, "Vacuum Connections and Fittings.")

A good vacuum-tight joint between the pump intake and connecting line can readily be made by sliding the correct size, heavy-walled rubber tubing (Welch No. 5518B) over the intake nipple. Insert the connecting line into the tubing so it butts flush against the nipple. Use of worm-screw band clamps is desirable, and/or sealing with vacuum wax or "Leak-Lock" (Welch Catalog No. 1372).

For permanent connections, remove either or both the intake nipple and exhaust dust cap, and screw the piping into the connections. See Page 14 for thread dimensions. Use a sealant such as "Glyptal" or "Leak-Lock" on the intake threads.

OIL LEVEL AND TYPE

To insure efficient operation, low maintenance and freedom from unnecessary noise and oil vapors, it is extremely important to use the proper type and quantity of oil. Welch Duo-Seal Oil has been specially developed over a period of years, to have the required viscosity, low vapor pressure and chemical stability. The vacuum guarantee on Welch Pumps applies only when Duo-Seal Oil is used. A sufficient supply of oil is furnished with each pump. Additional Duo-Seal Oil (Welch Catalog No. 1407K) is available in quart and gallon plastic bottles and in five gallon cans.

After pump has been running for at least fifteen minutes, check the oil level. It should be maintained between the oil-level marks, with the pump in operation. In general, the oil level will be slightly higher while the pump is running than when it is stopped. If the oil level gradually rises during prolonged operation, water or other vapor is condensing in the pump. When this occurs, the vented exhaust valve, on pumps so equipped, should be opened to purge the oil, or the oil should be changed.

The No. 1404 Pump does not have an oil-level window. In this pump the oil-level mark may be seen by removing the top plate. This requires the removal of two screws. In all No. 1404 Pumps, the top plate must be removed to add oil to the reservoir.

An explanation of the effect of too much or too little oil and oil contamination is contained on page 7, under the heading, "Oil Changes and Levels".

RECOMMENDED ACCESSORIES

Belt guards totally enclose the pulleys and belts, and are strongly recommended for the protection of personnel working near the pumps. Belt guards are furnished with mounted Nos. 1397 and 1398 Pumps and are available for all others. To service belts or pulleys, the outer half of the guard can be removed or folded down, depending on type. This can be done without use of tools. All pump bases made in the last five years have been predrilled to accept guard brackets. Older bases require drilling of two holes.

Exhaust filters are available for attachment to the exhaust port in place of the dust cap. Their use is recommended when it is necessary to operate the pump with relatively high gas flows. Any oil-sealed mechanical vacuum pump tends to discharge oil mist from its exhaust port when it is operating at high flow. Oil droplets entrained in the discharge air are removed by the combined action of a two-stage filter element. One stage consists of multiple layers of fine wire screen and the other of a special fiber. Oil is drained from the element, back through the discharge connection into the oil reservoir of the pump.

EXHAUST FILTERS:

No. 1417 for Nos. 1399, 1400, 1405, 1406 and 1410 Vacuum Pumps. (2" diameter x 4¾" high, ¾ - 20 male thread)

No. 1417A for Nos. 1402 and 1403 Vacuum Pumps. (6" diameter x 7½" high, 1 - 20 male thread)

No. 1417B for No. 1397 Vacuum Pump. (7" diameter x 10" high, 1-¾ - 20 male thread)

REPLACEMENT FILTERS:

No. 1417F for 1417 Filter; No. 1417G for No. 1417A Filter; No. 1417H for No. 1417B Filter.

BELT GUARDS

No. 41-0791 for No. 1397; No. 41-2496 for No. 1398; No. 1399G for No. 1399; No. 1400G for Nos. 1400 and 1410; No. 1404G for Nos. 1404 and 1406; No. 1405G for Nos. 1402, 1403 and 1405.

INSTALLATION OF Nos. 1392 & 1392A

These combinations consist of a No. 1400B Duo-Seal Pump with motor and a modified, two-stage metal diffusion pump, mounted on a common base. Installation is the same as that for other Welch Duo-Seal Pumps with the following additional requirements.

Connect diffusion pump intake (large diameter) to the vacuum system, preferably by brazing or silver soldering. Use as short a connection as possible with as large a diameter as possible.

Connect diffusion pump heater and electric motor to 115 V, 60 cycle power supply, with separate cords and switches provided.

Connect diffusion pump to coolant supply. No. 1392 uses a water-cooled diffusion pump and requires 0.08 G.P.M. of water at normal temperatures. Connect water supply to tubing at intake stack. The No. 1392A uses an air-cooled diffusion pump. For best results a small blower or fan with a capacity of 20 C.F.M. should be used to direct air across the cooling fins, impinging first on the intake stack.

Check system for leaks before filling diffusion pump with pump fluid.

Fill the diffusion pump with 55 c.c. of No. 1391K Octoil Pump Fluid supplied. This may be accomplished by removing the drain plug, starting the mechanical pump and sucking the pump fluid into the boiler through a clean length of rubber tubing. Use a new drain plug gasket and replace drain plug while the mechanical pump is running. Turn off mechanical pump. More complete instructions are furnished with the Nos. 1392 and 1392A pump assemblies.

OPERATION

GENERAL PROCEDURES

1. Remove intake and exhaust port plugs and install dust cap in exhaust port.
2. Check the oil level before operating and check it periodically during operation.
3. Use only clean Duo-Seal Vacuum Pump Oil.
4. All Welch Pumps, except No. 1404, contain an air filter screen in the intake port to prevent foreign particles from entering the pump. Greatest possible care should be exercised to exclude foreign particles from the intake line.
5. If corrosive vapors or excessive water vapor is evolved in the vacuum process, a cold trap should be placed in the vacuum line to prevent damage to the pump mechanism and contamination of the oil.
6. When the pump is not being used and is disconnected from the vacuum system, plug the intake to keep out dirt.
7. Carefully check connection and vacuum system for leaks.
8. Periodically check V-belt tension and pulley alignment. V-belt should be adjusted so that a firm downward pressure at the middle of the span will cause a deflection of ½" to ¾".

START-UP PROCEDURES

1. Turn on power, with intake closed (to minimize splashing).
2. Check for proper direction of rotation.
3. Check oil for proper level, with pump running.
4. The gurgling noise, characteristic of mechanical vacuum pumps when operating at high pressures, should disappear after a few seconds. If it does not, check to see if oil level is too low, or if there is a leak in the connecting lines.
5. Open intake to the vacuum system.

Nos. 1392 and 1392A Mechanical-Diffusion Pump Combinations START-UP

1. Turn on mechanical pump and evacuate the system to less than 500 microns.
2. Turn on diffusion pump coolant and heater (fresh oil will evolve the gases dissolved in it and this will tend to increase system pressure temporarily). The diffusion pump requires 20 to 30 minutes to reach normal operating temperature and full pumping capacity. If system pressure does not decrease within a few minutes after diffusion pump reaches operating pressure, turn off heater and recheck system for leaks.

VENTED EXHAUST

Vented exhaust valves are supplied with No. 1397, 1398, 1399 and 1402 Pumps, and they are available as optional accessories for the No. 1400 and 1405 Pumps. Vented exhaust valves can be field-mounted on any No. 1400 or 1405 Pumps which have serial numbers higher than 25500-0 and 26157-5 respectively. Single-stage pumps, other than the No. 1399, are not adaptable to the use of the vented exhaust.

The vented exhaust is used to prevent, or minimize, the condensation of vapors in the pump. Condensed vapors raise the vapor pressure of the oil, reducing the vacuum obtainable. These vapors can also form sludges with the oil, causing corrosion and eventual freeze-up. The vented exhaust is also used to purge previously condensed vapors which will generally re-evaporate as they are exposed to the low pressure of the intake cycle. Recondensation in the compression cycle is prevented by operating the pump with the vented exhaust valve open.

A vented exhaust is not equally effective on all vapors encountered in vacuum processing, so it does not always entirely eliminate contamination of the oil. It does, however, reduce the contamination so oil changes are not needed as frequently.

The vented exhaust valve consists of a hollow stem with a metal ball closure fitting into a conical seat in the valve port housing.

A fixed passage through the stem includes a ball check valve which prevents back-flow of air in the final compression stages. Counter-clockwise rotation of the valve stem unseats the ball, opening an air passage to the exhaust opening in the pump. One full turn of the valve stem fully opens the valve. Any fraction of a turn will open the valve correspondingly. Newer model pumps have a needle valve at the top of the valve stem to control the flow of air into the valve stem. These needle valves can be finely adjusted to any position between fully open and fully closed.

To eliminate water and other condensed vapors from forming in the pump, open the vented exhaust valve. This is done by loosening the knurled lock-ring and turning the valve stem one full turn counter-clockwise . . . tighten lock-ring. The needle valve, included on new pumps, is opened by turning counter-clockwise far enough to handle the volume of vapor. Experience with the system will enable the operator to quickly determine the proper needle valve position. As the volume of vapors diminish, the needle valve should be closed progressively. Older pumps are not equipped with a needle valve. On these older pumps, turning the valve stem one full turn counter-clockwise will give maximum venting — fractions of a full turn will give a corresponding amount of venting. When valve is fully closed, the pump will produce the highest possible vacuum under the existing conditions. If not needed, the vented exhaust valve should be closed. It is closed by turning the stem clockwise until fully seated, then adjust lock-ring seal accordingly. Finger pressure is sufficient to seat the needle valve and valve stem for a leak-tight seal.

SHUTDOWN PROCEDURES

1. Close the pump intake.
2. Turn off power.
3. Bleed in air through intake.
4. Cover intake nipple if pump is disconnected from vacuum system.
5. If pump is going to be out of service for a prolonged period, drain the oil and fill with new Duo-Seal Oil to prevent the possibility of corrosion from contamination.

Nos. 1392 and 1392A Mechanical-Diffusion Pump Combinations SHUTDOWN

1. Turn off diffusion pump heater.
2. Continue cooling until diffusion pump boiler is cool enough to touch.
3. Shut off coolant supply.
4. Turn off mechanical pump.
5. Admit air to diffusion pump intake.

NOTE—To avoid decomposition, do not expose diffusion pump fluid to pressures above 1 mm Hg (Torr), while hot. If pressure rises above 1 mm Hg, turn off pump heater immediately and maintain cooling of pump.

ROUTINE MAINTENANCE

The need for routine maintenance of the pump is usually quite apparent. In most cases the problems can be solved with very little down time. The following paragraphs cover the most common of these problems. Routine maintenance for the Nos. 1392 and 1392A mechanical-diffusion pump assemblies is at the end of this section. Major repair, requiring the disassembly of the pump, is covered later in this manual, starting on page 11.

DRIVE PROBLEMS

If pump will not run, turn off switch. Check the fuse and electrical connections to be sure power is present to the motor. If power is present, proceed as follows: Remove V-belt. Rotate motor pulley and pump pulley clockwise, by hand. If motor is stuck, it will have to be replaced or repaired. If pump is jammed, it will have to be disassembled (see "Major Repairs," page 11). If the motor turns freely by hand, turn on switch, with V-belt removed. If the motor does not work, it will

have to be replaced or repaired. If the motor operates normally and the pump pulley turns freely, replace V-belt and check the belt tension. A firm downward pressure at the middle of the belt span will cause a deflection of ½" to ¾" when the tension is correct. To increase or lessen the tension, loosen motor mounting bolts and slide motor away from or toward the pump. If the belt is too tight, it will cause excessive wear on the pump. It it's too loose, it will slip, reducing the pump's efficiency and cause excessive belt wear. Lubricate motor as directed on motor plate. The motors furnished with Welch Pumps are sleeve-bearing type. With normal use they require lubrication about every three years.

Periodically check the set screws on the pulleys and tighten if necessary.

VACUUM PROBLEMS

A decrease in the vacuum system's efficiency will be apparent by a decrease in the ultimate vacuum attainable, and/or an increase in the time required for evacuation. This failing is usually caused by leakage or unusual out-gassing. It is rarely the fault of the pumping system.

To operate at maximum efficiency, the system must be thoroughly clean. Check all connections for leaks, as outlined on page 15, "Leak Detection". If the system is completely clean and free from leaks, and unwarranted vacuum problems still exist, the pump should be checked.

The most common cause of a mechanical pump's loss in efficiency is contamination of oil. It is caused by condensation of vapors and by foreign particles. Condensed vapors increase the vapor pressure, reducing the ultimate vacuum attainable. Foreign particles and some vapors form sludges with the oil. These sludges impair sealing and lubrication, and can cause eventual "freeze-up". A vented exhaust is helpful in removing vapors, especially water, but it is not equally effective on all foreign substances; therefore, periodic oil changes are necessary to maintain efficient operation of the system. The required frequency of changing oil varies, depending on the particular system. Experience with the process will help you determine the normal period of operation before an oil change is necessary.

OIL CHANGES AND LEVEL

To change oil, disconnect the pump from the system, if possible. Warm the oil by operating the pump with the intake closed, for approximately 15 minutes. Stop the pump and remove the oil drain cap. Most of the oil will drain out freely. USE CAUTION — *oil will be hot!* The small residue remaining in the pump can be forced out by turning the pump pulley by hand, with the exhaust port closed and intake open. The oil will spurt out suddenly and should be deflected into the drain pan. *Extensive operation with the exhaust port sealed should be avoided, as excessive internal pressure may loosen the shaft seal.*

After removing all oil, close the drain and pour 3 or 4 ounces of clean Duo-Seal Oil into the intake port. Open exhaust port and run pump for a short period to completely circulate the new oil. Drain the flushing oil and force out residue, as above. Repeat flushing with new Duo-Seal Oil until flushing oil remains clean and free of color and foreign matter.

WARNING—Do not use solvents or light flushing oils. Their complete removal is difficult and their higher vapor pressures will prevent the attainment of high vacuum.

If the oil has thickened or contains sludges, it is advisable to remove the oil reservoir case and thoroughly clean out the case with clean, lint-free rags. In replacing the oil case, varnish a NEW gasket and position on the pump case. Tighten all screws uniformly. Also replace the shaft seal as explained under the heading, "Oil Leakage".

After the pump is completely flushed, refill by pouring new Duo-Seal Oil into the exhaust port. Fill to proper level indicated on the sight glass. Replace dust cap.

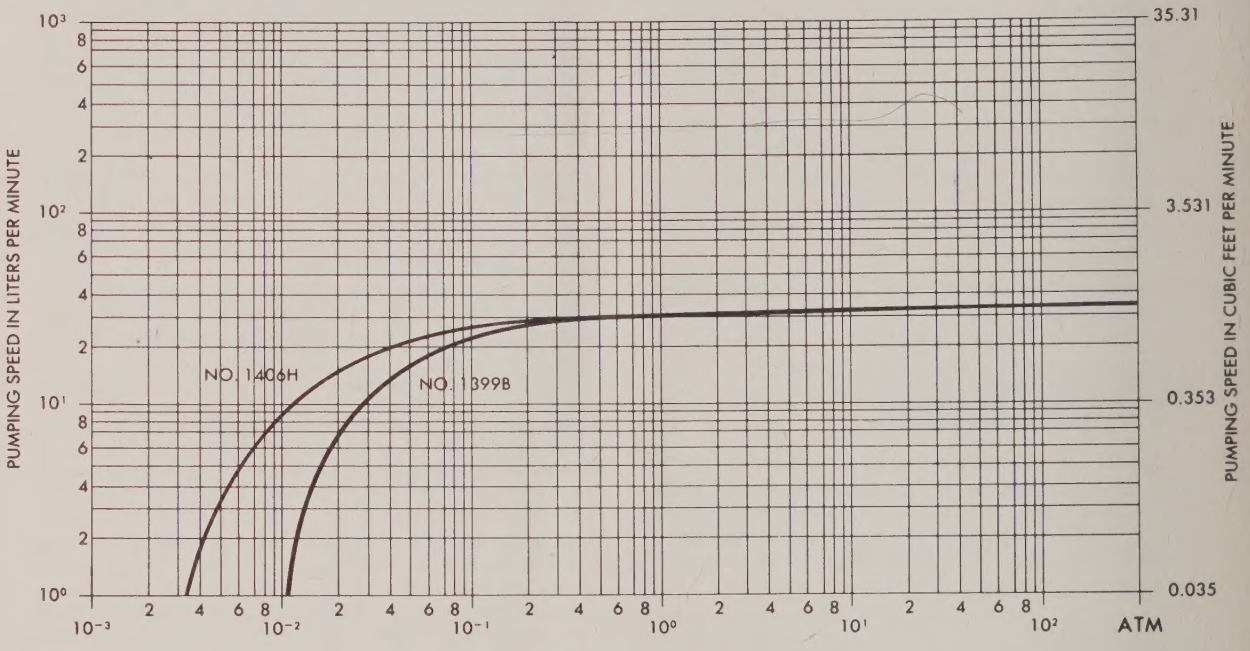
A gurgling noise is characteristic when high pressure air is drawn through the pump. It should disappear quickly as the intake pressure is reduced. If the pump continues to gurgle, the oil level may be too low. Insufficient oil does not give proper sealing or lubrication. Add oil through the exhaust port until it reaches the proper level. The oil level should be maintained between the marks on the sight glass, with the pump running. Level will drop when pump is stopped.

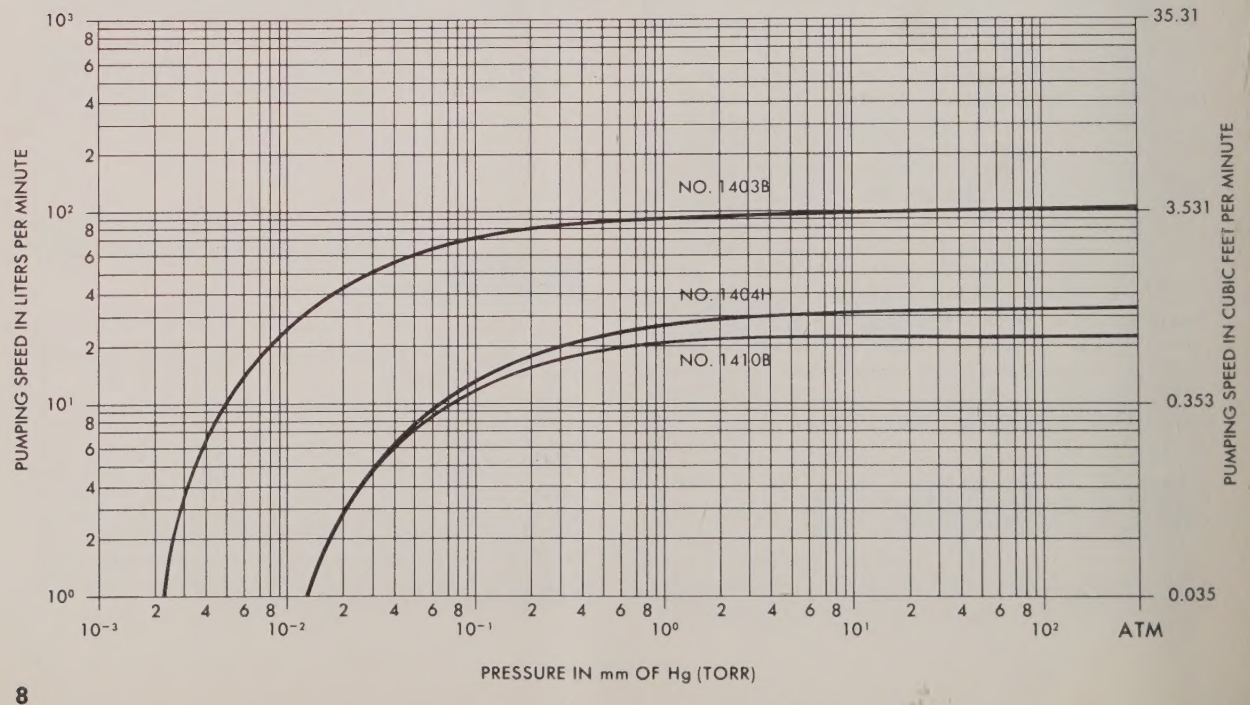
OIL LEAKAGE

Leakage of oil is readily apparent and easily corrected. The areas affected are:

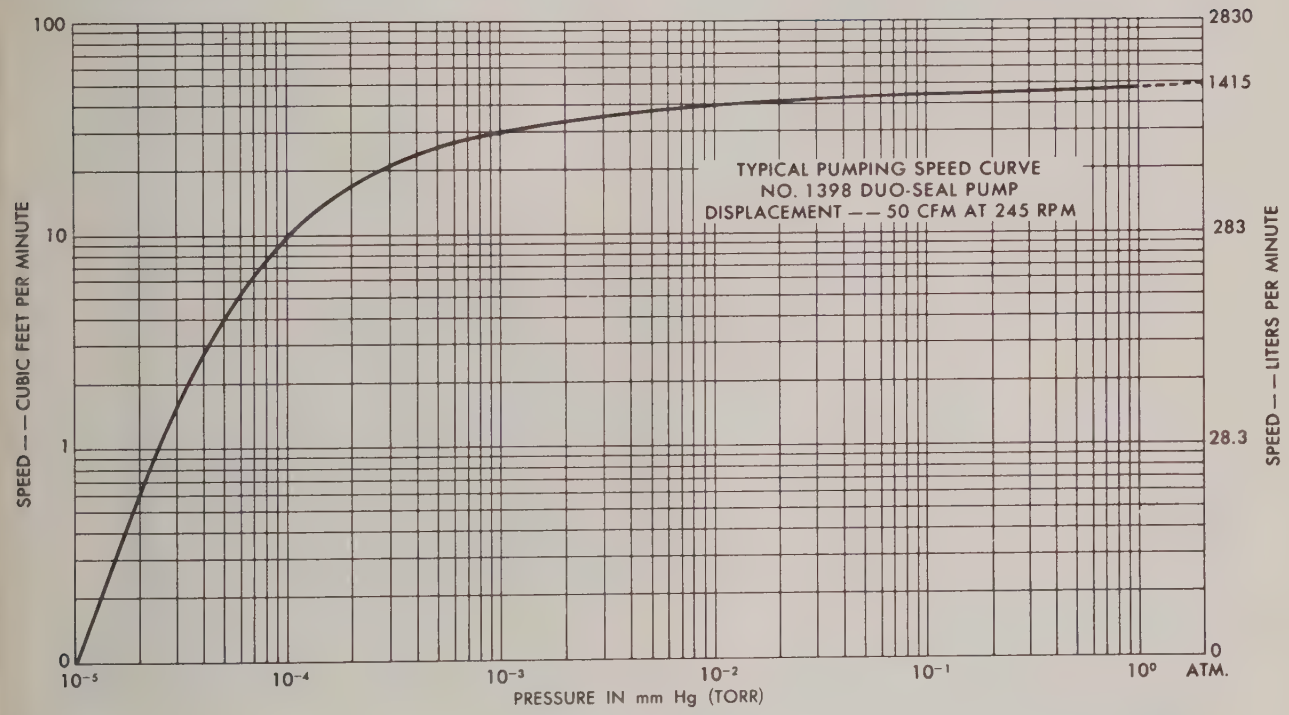
SHAFT SEAL—To replace shaft seal, drain oil, remove the pump pulley and key, and all parts of the seal. Clean the shaft and inspect it for any burrs or nicks. Carefully hone any damaged areas with fine emery paper. Hone the key way to remove sharp edges. Place new gasket on the pump casing (do not use cement). Carefully slide the replacement seal over the shaft and position against the pump housing. Align screw holes and tighten screws uniformly. *Instructions are included with replacement seals.*

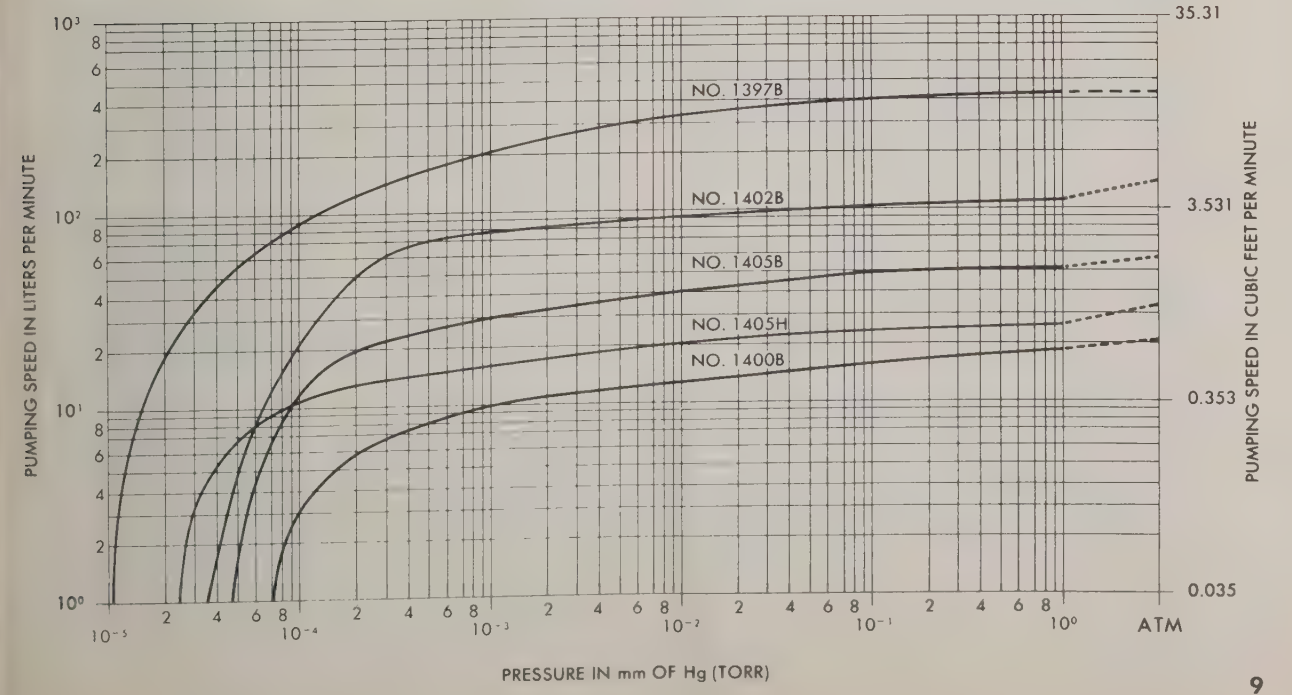
WELCH *DUO-SEAL* VACUUM





MP PERFORMANCE CURVES





OIL LEVEL SIGHT GAUGE—Unless the glass disc is damaged, it is generally only necessary to replace the inner and outer rubber gaskets. Drain oil and remove all parts of the oil level gauge. Insert new inner tension washer into counterbored seat in casing. Place glass disc in position. Mount new outer rubber washer over glass disc and into seat. Place oil window cover into position and tighten the 4 fillister head screws uniformly. The oil level gauge on the No. 1406 Pumps consist of a glass disc mounted in a metal ring. This assembly is mounted by pressing it into the opening in the case. A damaged unit can be easily knocked out.

OIL DRAIN CAP—Should a leak develop at the oil drain, replace the rubber disc within the drain cap. The old disc can be pried out with a stiff wire or pointed tool. Press the new disc firmly into the cap.

OIL CASE—If oil leaks at the oil case seal, drain the oil from the pump and remove case and gasket. Thoroughly clean the sealing surfaces of the case and pump. Varnish a new gasket and place in position. Mount case and thoroughly tighten all screws.

VENTED EXHAUST

Should the seat of the needle valve wear so that it will not seal with hand pressure, the valve stem should be replaced.

AIR FILTER REMOVAL AND CLEANING

With the exception of No. 1404 Pumps, all Welch Duo-Seal Pumps are equipped with an air filter screen. It is located below the pump intake port and functions as a trap for solids, which could cause damage to the pump. Such particles are usually the result of an implosion in the vacuum system. Unless the screen has been damaged, the filter may be removed and cleaned in the following steps:

1. Turn off the pump. (Drain oil in No. 1406 Pump)
2. Remove the intake cover.
3. Lift out air filter. (The air filter on the No. 1398 is a two piece screen attached to the intake elbow.)
4. Tap filter on clean disposable surface to remove solid particles. If further cleaning is required, rinse thoroughly in clean acetone followed by a rinse in clean alcohol and then a rinse in distilled water. Dry in stream of hot, dry air.
5. Replace the cleaned filter in intake area.
6. Use a new intake cover gasket and coat both sides with varnish. (The 1398 has a rubber O-ring rather than a gasket that should be replaced.)
7. When varnish is tacky, mount gasket in position on pump casting.
8. Replace intake cover and tighten screws evenly.
9. Fill pump with clean Duo-Seal Oil (Check level after running pump for a few minutes.)

Nos. 1392 and 1392A Mechanical-Diffusion Pump Combinations

The No. 1400 mechanical pump should be maintained and repaired as directed in the preceding instructions. The following procedures should be followed as routine maintenance of the diffusion pump.

OIL CHANGE—The pump fluid should be inspected periodically for color change and odor. If the fluid is slightly darkened and has no odor, a simple change of fluid is normally all that is needed. Follow the technique described under "Installation Procedures". If the fluid has developed a noticeable odor, it is recommended that the pump be cleaned in the following method.

CLEANING—Remove diffusion pump from system. Thoroughly drain oil through drain outlet (slight warming is helpful). Rinse pump with acetone and fill with a 50% solution of Caustic Soda (use care in handling). By using pump heater, boil Caustic Soda solution in pump for approximately 30 minutes. Drain caustic solution and rinse with clean, hot water. Rinse with acetone and dry with stream of warm, dry air. Replace drain plug and reinstall pump in system (replace drain plug gasket each time a plug is removed). Fill pump with 55 cc. of new "Octoil" pump fluid.

PUMP HEATER—If burn-out occurs, the heater can easily be removed and replaced. Remove holding nut at bottom of boiler and lower heater to remove. *Additional instructions are included with the pump.*

CHECKING PUMP PERFORMANCE

An excellent criterion of the condition of a mechanical pump is the ultimate vacuum it will achieve. This can be easily measured by connecting a suitable gauge to the intake of the pump and operating the pump until the highest vacuum reading is obtained.

This procedure can be used as a quick test to determine the need for maintenance and repair. Also, as a final test after all the necessary routine maintenance procedures have been followed. If the pump does not achieve or closely approach the performance of a new pump, the need for major repair is clearly established. Welch Duo-Seal Pumps are fully tested at the factory with upright, untrapped McLeod gauges. Other gauges, such as the Pirani or Thermocouple vacuum gauges can be used if allowance is made for the inherent difference in readings. See "Vacuum Techniques" in this manual for the explanation of gauges.

MAJOR REPAIRS

WELCH REPAIR SERVICE

With proper care, Welch Duo-Seal Vacuum Pumps can be depended on to give many years of reliable service. Should major repairs, which require disassembly of the pump mechanism, become necessary, it is strongly recommended that the pump be returned to the factory for reconditioning.

The basic working parts of Duo-Seal Pumps are machined to very close tolerances and require assembly on special fixtures, and with special tools by mechanics who are highly skilled at this work. It is our experience that the majority of pumps repaired by others fail to operate with maximum efficiency. It is usually still necessary to return them to the factory for proper repair.

The Welch Scientific Company maintains complete repair departments strategically located at the addresses shown on the back page. These facilities are well equipped and staffed with experts to insure prompt reconditioning of all returned pumps. Broken, worn, scored or corroded parts are replaced with new parts and the pump is thoroughly run-in and tested until it exceeds the performance requirements of the original guarantee.

WELCH EXCHANGE SERVICE

A rapid pump exchange service is offered by Welch through all of its offices to save customers the normal down-time required for factory reconditioning. A pool of reconditioned pumps is maintained for this service. Under this plan, a customer's repairable pump will be replaced by a factory reconditioned pump of the same catalog number. The prices for this exchange are as follows (subject to change without notice):

PUMP CAT. NO.	REPLACEMENT CHARGE PLUS CUSTOMER'S REPAIRABLE PUMP	PUMP CAT. NO.	REPLACEMENT CHARGE PLUS CUSTOMER'S REPAIRABLE PUMP
1397	$225.00	1403	$90.00
1398	500.00	1404	70.00
1399	45.00	1405	95.00
1400	60.00	1406	70.00
1402	135.00	1410	45.00
F. O. B. Our Plant or Branch			

Exchange Service Instructions—Simply order a factory reconditioned replacement pump of the same catalog number as the pump you wish to replace. It will be shipped to you immediately. Your pump may then be returned to the factory in the same container. You will be billed the full price of the replacement pump, at time of shipment. On receipt of your pump at the factory, a credit memorandum will be issued to you, covering the difference between the billed charge and the exchange allowance for your pump.

If your pump is not a standard model, the cost of parts and labor necessary to convert it to a standard model will be added to the cost of the replacement pump. If your pump is not repairable, you will be notified. You may then purchase a new pump and return the replacement to us when you receive the new unit. *Return the pump only—do not send motor or base.*

REPLACEMENT PARTS ORDERING INSTRUCTIONS

The parts list on the next page includes all of the items necessary to affect the repairs or replacements described in this manual. The numeral in parentheses, preceeding the part number, indicates the total quantity required of the item. When ordering replacement parts, list the quantity required, the part number and description. Shipment will be made immediately from stock.

REPLACEMENT PARTS LIST

DESCRIPTION OF PARTS	PUMP CATALOG NUMBERS AND PART NUMBERS									
	1397	1398	1399	1400	1402	1403	1404	1405	1406	1410
EXHAUST PORT DUST CAP.	41-1501		41-1345	41-1345	41-0612	41-0612		41-1345	*41-1345 or 1151C	
INTAKE										
Nipple	41-1493		41-0920	41-0920	41-0993	41-0993	41-0924	41-1274	41-0920	41-0920
Nipple Washer	41-0961				41-0491	41-0491	41-0570	41-0409		
Cover Gasket	41-1495		41-2375	41-0383	41-0234	41-0234		41-1308	41-1310	41-0258
Air Filter Screen	41-0937	41-2523 41-2524	41-0306	41-0890	41-0660	41-0660		41-0891	41-0877	41-0306
OIL CASE GASKET	41-1496	41-2518	41-1052	41-1052	41-0403	41-0403		41-1308		41-1052
OIL DRAIN CAP	41-1151	41-2499	41-1166	41-1166	41-1166	41-1166	41-1166	41-1166	41-1166	41-1166
OIL DRAIN CAP DISC	41-1172		41-1192	41-1192	41-1192	41-1192	41-1192	41-1192	41-1192	41-1192
OIL LEVEL GAUGE										
Tension Washer	41-1266	41-1266	41-1266	41-1266	41-1266	41-1266		41-1266		41-1266
Glass Disc	41-1268	41-1268	41-1268	41-1268	41-1268	41-1268		41-1268	41-0555	41-1268
Outer Gasket	41-1267	41-1267	41-1267	41-1267	41-1267	41-1267		41-1267		41-1267
Window Cover	41-1061	41-1061	41-1061	41-1061	41-1061	41-1061		41-1061		41-1061
SHAFT SEAL	41-1491	41-2491	1401E	1401E	1401D	**1401A or 1401E	1401E	1401E	1401E	1401E
Gasket	41-1494	41-2515	included	included	included	included	included	included	included	included
Screws	(4)2-01-6120	2-01-0110	included	included	included	included	included	included	included	included
VALVE, EXHAUST										
Clock Spring	41-2161		41-1239	41-1239	41-2161	41-0695	(2)41-1239	41-1281	41-1281	41-1239
VALVE, EXHAUST STAGE PRESSURE RELIEF										
Clock Spring	41-0992	41-2506			41-0992	41-0992				
Steel Ball	4-40-1200	4-40-2000			4-40-1200	4-40-1200				
VALVE, FIRST STAGE CONVERSION										
Gasket	41-1508									
O-Ring	41-1507	41-1507								
Spring Unit	41-1504	41-1504								
Bellows	14-1505	41-1505								
Valve					(2)41-2157					
Spring					(2)41-2158					
VALVE, FIRST STAGE PRESSURE RELIEF										
Valve	41-2248	41-2398								
Spring	41-2244	41-2507								
Tension Strip	41-2247	41-2485								
PRESSURE CROSS			1399T							41-1186
Adapter										41-1184
PUMP PULLEY	41-1492	41-2510	41-2192	41-2191	41-2174	41-2194	41-2194	41-2194	41-2194	41-2191
Key	41-1490	41-2514	41-0624	41-0624	41-0624	41-0624	41-0624	41-0624	41-0624	41-0624
DUO-SEAL OIL	1407K	1407K	1407K	1407K	1407K	1407K	1407K	1407K	1407K	1407K
EXHAUST FILTER	1417B	41-2495	1417	1417	1417A	1417A		1417	1417	1417
Repl. Element	1417H	41-2516	1417F	1417F	1417G	1417G		1417F	1417F	1417F
VENTED EXHAUST VALVE	included	included	included	1414	included			1414A		
Repl. Stem Assembly	41-2289	41-2497	41-2289	41-2289	41-2348			41-1258		
O-Ring	41-2364		41-2364	41-2364				41-2364		
MOUNTING PARTS										
BASE	41-1475	41-2475	41-0752	41-0788	41-2052	41-0779	41-1295	41-0794	41-0753	41-0788
Rubber Feet	(4)41-0588		(4)41-0929	(4)41-0929	(4)41-0929	(4)41-0929	(4)41-0929	(4)41-0929	(4)41-0929	(4)41-0929
Screws	(4)2-01-0312		(4)2-02-5708	(4)2-02-5708	(4)2-02-5708	(4)2-02-5708	(4)2-02-5708	(4)2-02-5708	(4)2-02-5708	(4)2-02-5708
Nuts	(4)2-35-3800									
PUMP										
Bolts	(4)2-01-0516	(8)2-01-0520	(4)2-01-0312	(4)2-01-0312	(4)2-01-0312	(4)2-01-0312	(2)2-01-0312	(4)2-01-0312	(4)2-01-0312	(4)2-01-0312
Washers	(4)2-63-0593	(8)2-63-0593	(4)2-61-3100	(4)2-61-3100	(4)2-61-3100	(4)2-61-3100	(2)2-61-3100	(4)2-61-3100	(4)2-61-3100	(4)2-61-3100
Nuts	(4)2-31-2521	(8)2-31-2521	(4)2-35-3800	(4)2-35-3800	(4)2-35-3800	(4)2-35-3800	(2)2-35-3800	(4)2-35-3800	(4)2-35-3800	(4)2-35-3800
MOTOR	**1 H.P.**	**3 H.P.**	**⅓ H.P.**	**⅓ H.P.**	**½ H.P.**	**½ H.P.**	**⅓ H.P.**	**⅓ ½**	**⅓ H.P.**	**⅓ H.P.**
Mounting Strips	(2)41-0669		(2)41-0670	(2)41-0670	(2)41-0669	(2)41-0669	(2)41-0670	(2) (2) 41-0670 41-0669	(2)41-0669	(2)41-0669
Bolts	(4)2-01-0312		(4)2-01-0312	(4)2-01-0312	(4)2-01-0312	(4)2-01-0312	(4)2-01-0312	(4)2-01-0312	(4)2-01-0312	(4)2-01-0312
Pulley or Clutch	41-0995	41-2513	41-2377	41-0549	41-1277	41-1247	41-0549 41-1181	41-1181 41-1277	41-0549	41-0549
V-BELT	(2)1397A	(4)41-2512	1399A	1400A	1405A	1405A	1406A	1405A	1406A	1400A
CORD, POWER, 115V	41-2500		**41-1058**	**41-1058**	**41-1058**	**41-1058**	**41-1058**	**41-1058**	**41-1058**	**41-1058**
230V	41-2551		**41-1057**	**41-1057**	**41-1057**	**41-1057**	**41-1057**	**41-1057**	**41-1057**	**41-1057**
BELT GUARD	41-0791	41-2496	1399G	1400G	1405G	1405G	1404G	1405G	1404G	1400G

*Use No. 1151C Dust Cap on all Model 1406 Pumps with serial number below 3956.
**Use No. 1401A Shaft Seal on all Model 1403 Pumps with serial number below 5132.

No. 1392 and 1392A MECHANICAL-DIFFUSION PUMP COMBINATION REPLACEMENT PARTS

DESCRIPTION OF PARTS	No. 1400 DUO-SEAL PUMP (SEE LARGE TABLE, THIS PAGE)	No. 1392 DIFFUSION PUMP (Water-Cooled)	No. 1392A DIFFUSION PUMP (Air-Cooled)
DIFFUSION PUMP		1391	1394
Heater—135 Watt, 115 Volt		1391H	1391H
Octoil Pump Fluid			
150 ml.		1391K	1391K
500 ml.		1391L	1391L
Silicone Pump Fluid			
DC-702—200 ml.		1391T	1391T
—500 ml.		1391R	1391R
DC-703—200 ml.		1391U	1391U
—500 ml.		1391S	1391S
DC-704—500 ml.		1391W	1391W

PUMP SPECIFICATIONS

PUMP PERFORMANCE

A vacuum pump is best described by its pumping speed, in volume per unit of time, at various pressures. *Example: 100 liters/minute at 0.1 micron.* This measurement is independent of the vacuum system with which it is used. An examination of the speed curves on pages 8 and 9 will show that Welch Duo-Seal pumps maintain high volumetric efficiency, almost down to their ultimate vacuums. Another important feature of a vacuum pump is the ultimate vacuum that it can obtain.

The above data is necessary to determine the proper size and type to best obtain the desired results, with a specific vacuum system.

WELCH DUO-SEAL VACUUM PUMP SPECIFICATIONS

PUMP CAT. NO.	ULT. PRESSURE mm Hg (McLeod)	FREE AIR DISPLACE. (liters/min.)	NO. OF STAGES	APPROX. PUMP SPEED (RPM)	VENTED EXHAUST	OIL CAPACITY (milliliters)	PUMP PULLEY DIA.	RUBBER TUBING BORE	INTAKE PORT THREAD
*1392	1×10^{-6}	600.(1×10^{-4})				55			
1397	1×10^{-4}	425.	2	365	Included	1230	12″	1-5/8″	1-3/4″–20
1398	1×10^{-4}	1400.	2	245	Included	2500	19″		
1399	1.5×10^{-2}	35.	1	750	Included	450	7″	7/16″	3/8″ IPS
1400	1×10^{-4}	21.	2	450	Optional	550	7″	7/16″	3/8″ IPS
1402	1×10^{-4}	140.	2	525	Included	2200	10″	13/16″	1″–20
1403	5×10^{-3}	100.	1	375		1400	10″	13/16″	1″–20
1404	2×10^{-2}	33.4	1	300		2300	10″	5/8″	
1405B	1×10^{-4}	58.	2	525	Optional	250	10″	5/8″	3/4″–20
1405H	or 5×10^{-5}	33.4	2	300	Optional	250	10″	5/8″	3/4″–20
1406	5×10^{-3}	33.4	1	300		60	10″	5/8″	3/8″–IPS
1410	2×10^{-2}	21.	1	450		450	7″	7/16″	3/8″–IPS

*No. 1392 Mechanical Pump Specifications are the same as No. 1400 in table. No. 1392 Diffusion Pump Specifications are listed in table.

946 Milliliters = 1 Quart

MOTOR SPECIFICATIONS FOR WELCH DUO-SEAL VACUUM PUMPS

(to operate pump at proper speed)

PUMP CAT. NO.	MOTOR RATING		MOTOR PULLEY		BELT GUARD
	H.P.	R.P.M.	DIAMETER	BORE	
1397B	1	1725	2-1/2″	5/8″	Included
1398M	3	1160	4″	1-1/8″	Included
1399B	1/3	1725	3″	1/2″	Optional
1400B	1/3	1725	2″	1/2″	Optional
1402B	1/2	1725	3″	5/8″	Optional
1403B	1/2	1725	2-1/4″	5/8″	Optional
1404H	1/3	1725	2″	1/2″	Optional
1405B	1/2	1725	3″	1/2″	Optional
1405H	1/3	1725	2″	1/2″	Optional
1406H	1/3	1725	2″	1/2″	Optional
1410B	1/3	1725	2″	1/2″	Optional

N.B. When ordering motor, specify voltage.

VACUUM TECHNIQUES

VACUUM CONNECTIONS AND FITTINGS

The choice of line sizes and fittings, such as valves, can have a very marked effect on the pumping speed at the vacuum vessel. Any connection placed between the pump and the vessel creates an impedance to the flow of gas. This is particularly true at low micron pressure where the gas flow is substantially molecular in character. It is then dependent on the kinetic activity of the molecule, bringing it to the intake of the pump.

It has been shown that the conductance of a tube is proportional to the cube of the diameter (D^3) and inversely proportional to its length (L). Therefore, it is imperative that the connecting lines be as large in diameter and as short in length as practical. For best results, the diameter of the connecting tube should be as large as the diameter of the pump intake. The effect of line impedance on the net pumping speed (S) can be seen in the following relationship:

$$1/S = 1/S_1 + 1/C$$

(S_1 is speed of pump in liters per second. C is the conductance of the tubing.)

To avoid a large reduction in pumping speed at the vacuum vessel, it is clear that the conductance of the line must be considerably greater than the speed of the pump. For example, if the conductance is equal to the speed of the pump, the net speed will be one-half that of the pump.

If metal piping or tubing is used, it is preferable to solder or braze all connections. Where threaded joints must be used, screw the members together several turns, coat the remaining threads with "Glyptal" or "Leak-Lock" and screw together tightly. Flanged connections with Elastomer O-ring gaskets make excellent demountable joints.

Where glass tubing is used between the system and pump intake, joints can be made by butting the ends of the two sections together in a short section of rubber tubing. This type joint can also be used with metal-to-metal or glass-to-metal tubing. After assembly, coat the ends of rubber tubing with vacuum grease, such as DC Silicone Grease (available from Welch). Permanent glass-to-metal seals can be made by the use of "Kovar" glass-to-metal seals.

Standard tapered and ball-and-socket joints should be coated with a thin film of vacuum grease before assembly.

VALVES

Metal valves or glass stopcocks are generally used in the connecting line between the system and the pump. They provide a means of isolating the pump from the system. To minimize the impedance of flow, the valve openings should be as large as possible. Stopcocks should be lubricated with vacuum grease.

TRAPS

Where corrosive vapors or large quantities of condensable vapors result from vacuum processing, a cold trap should be used in the connecting line to the pump. It will help prevent damage to the pump mechanism and contamination of the oil.

The cold trap is installed so the vapors come in contact with the surface of the trap and are condensed. Commonly used refrigerants are liquid nitrogen or dry ice and acetone. The refrigerant to be used depends on the freezing point of the contaminants. A variety of glass cold traps are available from Welch.

When using a cold trap, the refrigerant should be maintained at a high level, to prevent warm-up of the trap. Warm-up of the trap may allow re-evaporation of the condensed vapors. The refrigerant cavity opening should not be obstructed, as the refrigerant boil-off can produce dangerously high pressures. If the trap becomes saturated, it should be disconnected from the system and the condensed vapors removed from the trap. An increase in pressure in the vacuum system will normally indicate that the trap has become saturated. When this occurs, the vapors are being evolved faster than they can be carried away.

To clean the trap, remove the refrigerant and allow the trap to warm up. Rinse off the condensed vapors with a suitable solvent. Thoroughly clean and dry the trap before reinstalling in the system.

VACUUM GAUGES

The type vacuum gauge to be used is determined largely by the pressure range to be measured. Pressures in the range produced by Welch Duo-Seal Pumps can be covered by McLeod, Dubrovin, Pirani or Thermocouple type gauges.

The McLeod gauge is used where high accuracy of measurement is required. The Pirani and Thermocouple gauges are electrical and give continuous readings of the total pressure. They are preferred where rapid pressure changes occur. The McLeod gauge does not measure condensable vapors; therefore, if vapors are present it will generally read lower than electrical gauges.

For higher vacuums in systems employing diffusion turbo-molecular or ion pumps, the hot filament ionization or the Philips gauge is used.

LEAK DETECTION

The importance of eliminating all leaks in a vacuum system is obvious when it is realized that a leak into the system, at atmospheric pressure, expands in volume by a factor of 750,000 to 10,000,000 or more. The pump must remove this added volume to maintain the desired vacuum. Fortunately a number of effective techniques for leak detection have been developed.

Large leaks can be located by pressurizing the system and painting the suspected area with a thick soap solution. Escaping air will produce soap bubbles.

Small leaks in glass systems can be located by probing with a Tesla Coil (available from Welch). This instrument is a high frequency, ungrounded, high potential spark coil with a pointed electrode. The discharge from the coil will pass through any minute opening and produce a pink glow at the location of the hole. In using a Tesla Coil, the electrode point should be held ¼″ to ½″ from the glass. It is not recommended for use in very thin-walled systems or adjacent to glass-to-metal seals.

Small leaks can also be detected by spraying a suspected area with acetone or gases rich in hydrogen, and observing a sudden change in pressure reading on an electrical gauge. (Pirani or Ionization type gauge). The difference in calibration of these gauges, for air and other gases, will produce a distinct change in the pressure reading. To use this method of detection, the system must be under vacuum and the gauge sensing tube must be located between the pump and the area to be probed. *Use extreme caution, as these materials are highly flammable!*

Locating very fine leaks requires a helium-sensitive, mass spectrometer leak detector. This instrument will locate leaks which cannot be detected by any other method. Numerous fine leaks can have a total effect of a large leak.

REPAIRING LEAKS

It is preferable that a permanent repair be made whenever a leak is located. Rewelding welded joints, refusion of glass or soldered joints, etc., are done by normal methods. Gasketed joints, which cannot be sealed by further tightening of bolts, should have the gasket replaced and/or the seal reground. Threaded joints should be loosened and the threads coated with "Glyptal" or "Leak-Lock", then retightened.

Temporary repairs can frequently be made by painting the area with "Glyptal" or "Leak-Lock".

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Vacuum Equipment and Techniques, Guthrie and Wakerling, (McGraw-Hill) 1949.

Procedures in Experimental Physics, J. Strong, (Prentice Hall) 1938.

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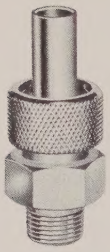
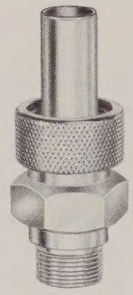
QUICK DISCONNECT COUPLING ASSEMBLIES



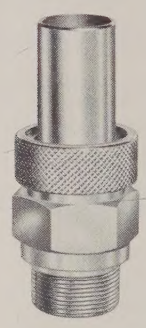
No. 1393A.

for pumps
1399
1400
1406
1410



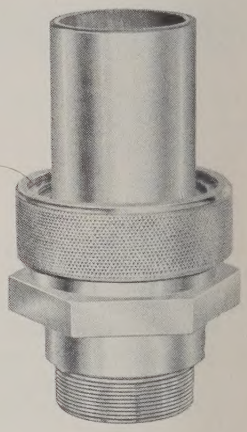
No. 1393B.

for pump
1405



No. 1393C.

for pumps
1402
1403



No. 1393D.

for pump
1397

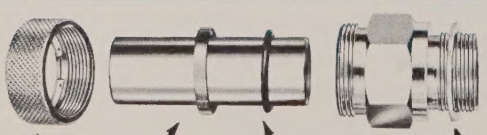
FOR EASY CONNECTION OF ANY METAL OR RUBBER TUBING OF PROPER DIAMETER

The Welch Quick Disconnect Coupling, when screwed into a Duo-Seal Pump instead of the standard intake nipple, permits direct, rapid attachment of metal or rubber vacuum tubing. The O-ring joint provides a vacuum-tight seal and permits quick disassembly. It is not necessary to dismantle the vacuum line when the pump must be removed. Simply unscrewing the threaded ring releases the connection.

Each coupling includes a short, stainless steel intake tube onto which rubber tubing may be slipped if desired. This intake tube should be replaced by a terminal tube of the same O.D. when a metal vacuum line is used.

for DUO-SEAL® Welch pumps

VACUUM PUMPS
CAN NOW BE DISCONNECTED
FROM SYSTEMS WITH JUST
"A Twist-of-a-Ring"



QUICK DISCONNECT COUPLINGS

Cat. No. 1393A. For Model 1399, 1400, 1406 and 1410 Pumps. Intake tube ½" O.D. **Each, $6.00**

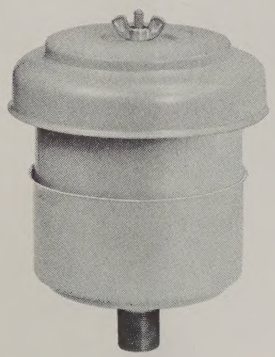
Cat. No. 1393B. For Model 1405 Pump. Intake tube ⅝" O.D. . . . . **Each, $7.50**

Cat. No. 1393C. For Model 1402 and 1403 Pumps. Intake tube ⅞" O.D. . . . . **Each, $8.50**

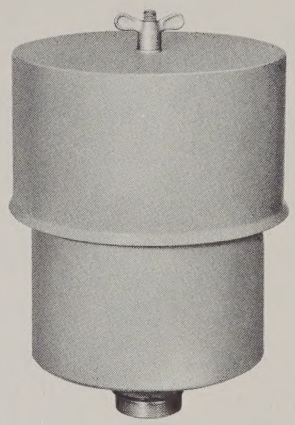
Cat. No. 1393D. For Model 1397 Pump. Intake tube 1¾" O.D. . . . . **Each, $26.00**

EXHAUST FILTERS

No. 1417.
for pumps
1399
1400
1405
1406
1410



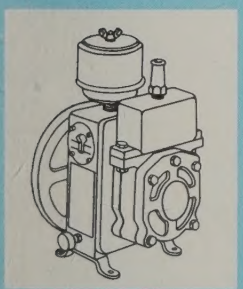
No. 1417A.
for pumps
1402
1403



No. 1417B.
for pump
1397

ELIMINATE OIL MIST AROUND EXHAUST KEEP VACUUM PUMP AREA CLEAN

Welch Duo-Seal Pumps operating at high pressures emit far less oil vapor from the exhaust than any other equivalent pump. Nevertheless, if you operate your Duo-Seal Pump frequently at the higher pressures, an Exhaust Filter is desirable.



The Welch Exhaust Filter simply screws into the exhaust port in place of the dust cap and effectively removes these oil vapors.

Oil droplets entrained in the discharge air are removed by the combined action of a two-stage filter element. One stage consists of multiple layers of fine wire screen and the other of a special non-organic fiber. Oil collected by these two components is drained from the element back through the discharge connection into the oil reservoir of the pump.

EXHAUST FILTERS

No. 1417. For Nos. 1399, 1400, 1405, 1406 and 1410 Pumps. 2" Dia. X 4¾" High, ¾-20 male thread. ..... **Each, $17.50**

No. 1417A. For Nos. 1402 and 1403 Pumps. 6" Dia. X 7½" High, 1-20 male thread ..... **Each, $30.00**

No. 1417B. For No. 1397 Pump. 7" Dia. X 10" High, 1¾-20 male thread. ..... **Each, $52.50**

REPLACEMENT FILTERS

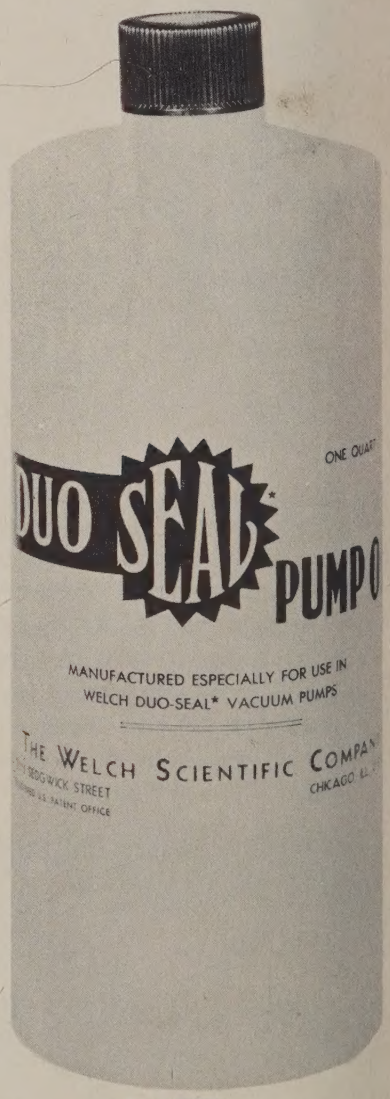
No. 1417F. For No. 1417 Filter. ..... **Each, $ 6.50**
No. 1417G. For No. 1417A Filter..... **Each, $12.00**
No. 1417H. For No. 1417B Filter. ..... **Each, $17.50**

SINCE 1880

WELCH *DUO-SEAL*® PUMP OIL

For All *Duo-Seal* Vacuum Pumps

WITH OUTSTANDING
Low Vapor Pressure
Chemical Stability
Ideal Viscosity



No. 1407K.

MADE UNDER A PATENTED PROCESS

Produced according to the most exacting specifications. Each batch must pass rigorous tests in our control laboratory before it can be released for use.

***DUO - SEAL* OIL IS SO DEPENDABLE THAT**

The high vacuum performance guarantee of Welch Duo-Seal Pumps applies ONLY when Duo-Seal Oil is used. Repeated tests prove that Duo-Seal Pumps perform best with Duo-Seal Oil. There can be no substitute for high quality.

FOR BEST RESULTS —

Whether you operate your Welch Duo-Seal Pump constantly or intermittently . . .

1. Check oil level periodically—
2. Inspect for contamination regularly—
3. Change oil when necessary—and—
4. Always use Welch Duo-Seal Pump Oil.

No. 1407K DUO - SEAL OIL, For Welch Mechanical Pumps. Best results can be expected when an oil of very low vapor pressure is used. This is the only oil recommended for use with Welch Duo-Seal Vacuum Pumps.

ORDER LARGER QUANTITIES AT A SAVING

Quart..$0.90	Gallon..$2.65	5-Gal. Drum..$10.85
12-Qt. Case..8.40	4-Gal. Case..9.00	55-Gal. Drum..79.75

MP MASTER
MA25579

SINCE 1880

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THE WELCH SCIENTIFIC COMPANY

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